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UNITED STATES DEPARTMENT OF AGRICULTURE

# BULLETIN No. 366

Contribution from the Office of Markets and Rural Organization. CHARLES J. BRAND, Chief.

Washington, D. C. PROFESSIONAL PAPER April 24, 1916.

# MANUFACTURING TESTS OF COTTON FUMIGATED WITH HYDROCYANIC-ACID GAS.

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## INTRODUCTION.

The spinning tests herein described were suggested by a joint committee of cotton manufacturers and officials of the Federal Horticultural Board, who met and discussed plans of preventing the introduction into the United States of the pink boll worm[1] with the importations of foreign-grown cotton. As hydrocyanic-acid gas had been found by that Board to be a practicable and successful fumigating agent[2] in the destruction of these pests, even though the larvæ were in the center of a compressed bale of cotton, it was decided that manufacturing tests should be made to determine whether the fumigation by this agent would cause any injury to the cotton fibers.

## SPINNING TESTS.

The manufacturing tests were conducted by the United States Department of Agriculture, under the direct supervision of the Office of Markets and Rural Organization. Through the courtesy of the president and manager the tests were made at the New Bedford

[1] Hunter, W. D., The Pink Boll Worm. Unnumbered publication. U. S. Department of Agriculture, Bureau of Entomology, August, 1914.

[2] For a description of this method of fumigation see U. S. Department of Agriculture, Federal Horticultural Board. Service and regulatory announcement No. 21, 1915.

NOTE.—This bulletin should be of interest to manufacturers and dealers in foreign-grown cotton and cotton yarns, also indirectly of interest to the domestic producers, manufacturers, and dealers in all staple cottons.

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Textile School, New Bedford, Mass., on two separate lots of cotton, a portion of each lot having been fumigated with hydrocyanic-acid gas under the supervision of the Federal Horticultural Board. In each lot the fumigated cotton was compared with nonfumigated cotton of the same lot.

The principal points taken into consideration during the spinning tests to determine whether the fibers were injured by the fumigation were (1) the percentage of waste, (2) the spinning qualities, (3) the tensile strength of the yarn. During the laboratory tests the following points were considered: (4) The bleaching properties of both the cotton and yarn, (5) the dyeing properties of the cotton and yarn, and (6) the mercerizing properties of the yarn.

In addition to the manufacturing tests, made by the Department of Agriculture, a number of manufacturing firms that regularly use foreign-grown cotton conducted tests in order to ascertain whether the fumigation of cotton with hydrocyanic-acid gas proved detrimental to their product. These tests were conducted in cooperation with officials of the Department of Agriculture.

Several manufacturing companies also sent yarns to Washington which were tested in the yarn testing laboratory of the Department of Agriculture for tensile strength. Two of these firms sent complete reports which included the comparative waste percentages of fumigated and nonfumigated cotton as found by them.

### STOCK OF COTTON.

In the tests conducted by the Department of Agriculture the first lot consisted of two 50-pound samples, one taken from a fumigated bale and one from a nonfumigated bale. Both bales were of Sakellaridis Egyptian cotton $1\frac{1}{4}$ inch in length of staple. The fumigated bale was fumigated with hydrocyanic-acid gas on at least five different occasions in a vacuum of 27 inches. The amount of sodium cyanide employed varied from 3 to 10 ounces per 100 cubic feet of chamber space with exposures ranging from thirty minutes to one hour. The volume of gas which penetrated this bale was fully ten times as much as that ordinarily used in accordance with the regulations prescribed by the Federal Horticultural Board. All other fumigated cotton referred to in this publication was exposed to hydrocyanic-acid gas in the presence of a 20-inch vacuum with 3 ounces of sodium cyanide per 100 cubic feet of chamber space with an exposure of one-half hour. The second lot consisted of 50-pound samples from each of six bales of Sakellaridis Egyptian cotton of $1\frac{1}{2}$ inches in length of staple.

Three of the bales were fumigated and three bales were nonfumigated. In the selection of the fumigated and nonfumigated cotton a careful comparison was made of grade and staple in order to secure equal values.

A few samples of fumigated and nonfumigated Peruvian and Chinese cottons were secured from the mills and chemical laboratory tests were made on these cottons in the department of chemistry and dyeing of the New Bedford Textile School.

### METHODS OF COMPARISON.

Each bale was given a mark so that it could not readily be identified while in the manufacturing processes as to whether it had been fumigated. The fumigated and nonfumigated cottons of each lot were opened and left standing overnight. They were run through the machines under the same conditions of speeds and settings, and where possible the fumigated and nonfumigated portions of each lot were placed side by side on the same machine, advancing together through the various processes of manufacture. Between each run the machines were cleaned thoroughly. Total weights were taken before and after the cotton was fed into the opener, finisher, cards, and combers respectively. Records of humidity were taken hourly and the humidifiers regulated accordingly, keeping the relative humidity as nearly uniform as possible for the respective lots.

### WASTE PERCENTAGES.

Table I gives the comparative waste percentages of the fumigated and nonfumigated cotton.

Lots No. 1 and No. 2 represent respectively the 1¼-inch staple and the 1½-inch staple, fumigated and nonfumigated cotton given separately, which were tested at the New Bedford Textile School, New Bedford, Mass. Lots No. 3 and No. 4 represent a digest of the reports received from the two manufacturing firms.

TABLE I.—*Waste percentages.*

[Based on net weight of cotton fed into each machine.]

| Kind of waste. | Lot No. 1. | | Lot No. 2. | | Lot No. 3. | | Lot No. 4. | |
|---|---|---|---|---|---|---|---|---|
| | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. |
| Opener: | | | | | | | | |
| Visible— | | | | | | | | |
| Dust room | 0.67 | 0.25 | 0.46 | 0.33 | ..... | ..... | ..... | ..... |
| Motes and fly | 1.06 | 1.50 | .87 | .67 | ..... | ..... | 1.45 | 1.47 |
| Total visible | 1.73 | 1.75 | 1.33 | 1.00 | 0.65 | .53 | 1.45 | 1.47 |
| Invisible | 2.53 | 1.75 | .29 | .62 | .83 | .55 | .05 | .03 |
| Total visible and invisible | 4.26 | 3.50 | 1.62 | 1.62 | 1.48 | 1.08 | 1.50 | 1.50 |
| Finisher: | | | | | | | | |
| Visible— | | | | | | | | |
| Dust room | .14 | .14 | .09 | .09 | ..... | ..... | ..... | ..... |
| Motes and fly | 1.43 | .96 | .74 | .65 | ..... | ..... | .47 | .48 |
| Total visible | 1.57 | 1.10 | .83 | .74 | .78 | .63 | .47 | .48 |
| Invisible | [1].14 | .13 | .18 | .04 | 1.15 | .61 | .03 | .03 |
| Total visible and invisible | 1.43 | 1.23 | 1.01 | .78 | 1.93 | 1.24 | .50 | .51 |

[1] Invisible gain, not loss, as a result of weather conditions.

TABLE I.—*Waste percentages*—Continued.

| Kind of waste. | Lot No. 1. | | Lot No. 2. | | Lot No. 3. | | Lot No. 4. | |
|---|---|---|---|---|---|---|---|---|
| | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. |
| Cards: | | | | | | | | |
| Visible— | | | | | | | | |
| Flat strippings | 3.26 | 3.49 | 4.59 | 4.44 | 6.44 | 5.92 | 3.67 | 5.61 |
| Cylinder and doffer strippings | .93 | 1.02 | 1.33 | 1.36 | 1.05 | .90 | .26 | .51 |
| Motes and fly | 1.72 | 1.01 | 1.01 | 1.22 | 3.26 | 2.25 | 1.85 | 1.85 |
| Total visible | 5.91 | 5.52 | 6.93 | 7.02 | 10.75 | 9.07 | 5.78 | 7.97 |
| Invisible | 1.09 | 2.03 | .50 | .27 | .91 | 2.22 | .09 | .19 |
| Total visible and invisible | 7.00 | 7.55 | 7.43 | 7.29 | 11.66 | 11.29 | 5.87 | 8.16 |
| Comber: | | | | | | | | |
| Visible | 11.68 | 12.21 | 13.55 | 13.62 | 19.48 | 18.88 | 16.10 | 15.28 |
| Invisible | ..... | ..... | .31 | ..... | 1.27 | .10 | .15 | 1.66 |
| Total visible and invisible | 11.68 | 12.21 | 13.86 | 13.62 | 20.75 | 18.98 | 16.25 | 16.94 |

The figures given in Table I are based on the net weight of stock fed into each machine. It will be observed that there is no decided indication of the superiority of either the fumigated or nonfumigated cotton. The percentages of waste fluctuate considerably, without being consistently in favor of either the fumigated or the nonfumigated stock. Similar differences would be expected to exist in the comparisons of any two bales of cotton selected for equal value.

Table II gives the total percentages of visible and invisible waste discarded by the respective waste-cleaning machines. The percentages here given are based on the net weight of cotton fed into the opener picker.

TABLE II.—*Visible, invisible, and total waste percentages.*

[Based on net weight of cotton fed into the opener picker.]

| Kind of waste. | Lot No. 1 | | Lot No. 2. | | Lot No. 3. | | Lot No. 4. | |
|---|---|---|---|---|---|---|---|---|
| | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. |
| Total visible and invisible waste pickers | 5.62 | 4.69 | 2.61 | 2.39 | 3.39 | 2.31 | 2.00 | 2.00 |
| Total visible and invisible waste cards | 6.61 | 7.20 | 7.23 | 7.12 | 11.28 | 11.03 | 5.75 | 8.00 |
| Total visible and invisible waste combers | 10.25 | 10.76 | 12.50 | 12.32 | 10.62 | 16.46 | 14.97 | 15.25 |
| Grand total visible and invisible waste | 22.48 | 22.65 | 22.34 | 21.83 | 25.29 | 29.80 | 22.72 | 25.25 |

There is no evidence of injury to the cotton indicated by the results of the visible and invisible percentages of waste discarded. In fact, Table II shows that in every case, except lot No. 3, the grand total waste discarded from the fumigated cotton was less than that discarded from the nonfumigated cotton. Should the results have been the reverse—that is, in favor of the nonfumigated cotton to the

same extent—the effects of the fumigation might have been seriously questioned. However, since the two tests at the textile school do not disclose any material difference between these lots it is assumed that the differences shown by the mill tests are the result of technicalities.

### MOISTURE TESTS.

The results of these tests were substantiated by moisture tests of the fumigated and nonfumigated cotton at the textile school, shown in Table III. The results of these tests indicate that the fumigation had no appreciable effect on the absorptive properties of the cotton.

TABLE III.—*Percentages of moisture in the cotton while in the manufacturing processes.*

| Process. | Lot No. 2. | | Difference. |
|---|---|---|---|
| | Fumigated. | Nonfumigated. | |
| Fed into opener | 8.10 | 7.76 | +0.34 |
| Finished lap | 8.09 | 7.66 | +0.43 |
| Card sliver | 6.55 | 7.60 | −1.05 |
| Comber sliver | 7.08 | 7.13 | −0.05 |

### SPINNING QUALITIES.

The numbers of yarn made at the textile school to ascertain the spinning qualities were 40's and 50's from the 1¼-inch cotton and 10's, 20's, 30's, 40's, 50's, 60's, 80's, and 100's from the 1½-inch cotton. Close observations were made by the men who actually were running the machines and also by those supervising the work and no difference was observed in the general spinning qualities.

### TENSILE STRENGTH.

In order to ascertain the tensile strength comparisons of the different lots of fumigated and nonfumigated cotton, a number of bobbins of the different numbers of yarn were sent from the textile school and the mills to the laboratory of the Office of Markets and Rural Organization of the Department of Agriculture for test purposes.

These tests were made by reeling off, in skeins of 120 yards each, the same numbers of yarn made from the different lots. The skeins were placed on racks[1] in order to keep them separate and to avoid tangling, after which they were removed one at a time in rotation and broken with a power yarn-tester, the downward stroke of the traverser moving at the rate of approximately 12 inches per minute. Hourly humidity records were taken and the humidifier was regu-

[1] Method originated by Dr. N. A. Cobb, Bureau of Plant Industry, U. S. Department of Agriculture.

lated accordingly in order to maintain as nearly as possible a constant relative humidity of 65 per cent.

Table IV gives the results of the tensile-strength tests.

Lots Nos. 1 and 2, respectively, represent the two lots of 1¼-inch and 1½-inch Egyptian cotton manufactured at the textile school, while Nos. 3, 4, 5, 6, and 7 represent five lots of cotton, each manufactured by a different representative manufacturing company. The small variations in the various numbers of yarn were standardized for comparison. The differences in tensile strength, in some instances, were in favor of the fumigated and, in some instances, in favor of the nonfumigated cotton.

TABLE IV.—*Tensile strength comparisons.*

(Made in Yarn Testing Laboratory of the United States Department of Agriculture.)

| Number of yarn. | Lot No. 1. | | Lot No. 2. | | Lot No. 3. | | Lot No. 4. | | Lot No. 5. | | Lot No. 6. | | Lot No. 7. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Breaking strength in pounds per skein of 120 yards. | | Breaking strength in pounds per skein of 120 yards. | | Breaking strength in pounds per skein of 120 yards. | | Breaking strength in pounds per skein of 120 yards. | | Breaking strength in pounds per skein of 120 yards. | | Breaking strength in pounds per skein of 120 yards. | | Breaking strength in pounds per skein of 120 yards. | |
| | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. |
| 15's | | | | | 302.11 | 303.9 | | | | | | | | |
| 20's | | | | | | | | | | | | | 108.48 | 102.70 |
| 22's | | | | | | | | | 102.30 | 106.45 | | | 115.38 | 115.48 |
| 40's | 39.98 | 37.56 | | | | | | | | | | | | |
| 50's | 27.28 | 27.35 | | | | | | | | | | | | |
| 55's | | | | | | | 27.51 | 28.20 | | | | | | |
| 75's | | | | | | | | | | | 24.88 | 26.05 | | |
| 80's | | | 26.45 | 28.05 | | | | | | | | | | |
| 84's | | | | | | | 8.32 | 7.66 | | | | | | |

TABLE V.—*Tensile strength comparisons.*

[Made by two representative cotton mills.]

| Number of yarn. | Lot No. 3—Breaking strength in pounds per skein of 120 yards. | | Lot No. 4—Breaking strength in pounds per skein of 120 yards. | |
|---|---|---|---|---|
| | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. |
| 27's | 114.8 | 112.8 | | |
| 57's | | | 30.25 | 30.60 |

It will be observed that in lot No. 3 the fumigated cotton produced the stronger yarn; in lot No. 4 the reverse was true.

### SINGLE-THREAD TEST.

In addition to the tests shown in Table IV several tests were made with a single-thread testing machine.[1] The results of these tests are

[1] These strength tests were made by William Smith, professor in charge of the carding and spinning department of the New Bedford Textile School, New Bedford, Mass.

shown in Table VI. The results of the single-thread tests are recorded in ounces, while the tensile strength in pounds per skein of the yarn taken from the same bobbins from which the single-thread tests were made is also given. In all cases where the skein tests are given in connection with the single-thread tests, the yarn was taken from the same bobbins.

TABLE VI.—*Single-thread test.*

[Made at the New Bedford Textile School.]

| | Number of yarn. | Lot No. 1. | | Lot No. 2. | |
|---|---|---|---|---|---|
| | | Fumigated. | Nonfumigated. | Fumigated. | Nonfumigated. |
| Ounces per single thread | 40's | 5.48 | 5.53 | ..... | ..... |
| Pounds per skein 60 yards | 40's | 49.3 | 46.9 | ..... | ..... |
| Ounces per single thread | 30's | ..... | ..... | 14.80 | 15.10 |
| Pounds per skein 60 yards | 30's | ..... | ..... | 56.25 | 56.50 |
| Ounces per single thread | 60's 2-ply | ..... | ..... | 16.58 | 16.41 |
| Pounds per skein 60 yards | 60's 2-ply | ..... | ..... | 58.20 | 60.50 |

The single-thread tests, judged from the comparative uniformity of breaks, did not disclose any superiority, either in the yarns made from the fumigated or from the nonfumigated cotton.

Two of the mills reported their findings as to the tensile strength of the cotton yarns they manufactured. These results are shown in Table V, under lots No. 3 and No. 4.

## CHEMICAL LABORATORY TESTS.

Investigations also were made in the laboratory of the New Bedford Textile School[1] to ascertain whether cotton treated with hydrocyanic-acid gas lost any of its bleaching, dyeing, or mercerizing value. The following numerical designations represent the cotton and cotton yarns used in these laboratory tests:

KIND OF COTTON.

Sample No. 1. 1¼-inch Sakellaridis Egyptian—fumigated.
1a. 1¼-inch Sakellaridis Egyptian—nonfumigated.
2. 1½-inch Sakellaridis Egyptian—fumigated.
2a. 1½-inch Sakellaridis Egyptian—nonfumigated.
8. Peruvian cotton, from center of bale—fumigated.
9. Peruvian cotton, from outside of bale—fumigated.
10. Peruvian cotton, from center of bale—nonfumigated.
11. Peruvian cotton, from outside of bale—nonfumigated.
12. Peruvian cotton, from center of bale—fumigated.
13. Peruvian cotton, from outside of bale—fumigated.
14. Peruvian cotton, from center of bale—nonfumigated.
15. Peruvian cotton, from outside of bale—nonfumigated.

Samples 1 and 1a, respectively, represent the fumigated and nonfumigated 1¼-inch Sakellaridis Egyptian cotton, the two bales from

[1] These tests were made by Everett Hinckley, professor in charge of the department of chemistry and dyeing, New Bedford Textile School, New Bedford, Mass.

which these samples were taken being previously referred to as lot No. 1. In a like manner 2 and 2a represent the 1½-inch fumigated and nonfumigated cotton previously referred to as lot No. 2. Samples 8 to 15, inclusive, were selected from Peruvian cotton received from a manufacturing company. The cotton in samples 1, 2, 8, 9, 12, and 13 was fumigated with hydrocyanic-acid gas.

### BLEACHING OF RAW COTTON.

Samples of Nos. 2 and 2a were bleached by treating as follows:

Method *a*. Not scoured. Bleached with a solution obtained by the electrolysis of salt containing 0.5 gram of chlorine per liter. In future this solution will be designated as "electrolytic chlorine."

Method *b*. Scoured in a solution containing 1 gram of soda ash in each 10 cc. then bleached as in *a*.

Method *c*. Treated with 2 per cent acetic acid and bleached as in *a*.

Finally all the samples were blued with 0.001 per cent of blue-violet acid dye.

Methods *a*, *b*, and *c* are the usual processes for obtaining white cotton for spinning except that the usual quantity of bleaching agent used was reduced in these tests in order to magnify any variation in the results obtained. No differences in the results of any of the methods on the two samples were apparent, which indicates fumigating the cotton with hydrocyanic-acid gas had no appreciable effect upon the bleaching qualities of the cotton used in any of the tests.

To test the effect of fumigation on the various bleaching agents commonly used the following tests were carried out on samples No. 2, 2a, and 8 to 15, inclusive:

Method *d*. The cotton was boiled two hours in a 10 per cent solution of soda ash and bleached cold in "electrolytic chlorine" containing 2 grams of chlorine per liter.

Method *e*. The cotton was treated as in *d* except that chloride of lime solution containing 8 grams of chlorine per liter was used as the bleaching agent.

Method *f*. The cotton was treated as in *d* except that an alkaline solution of sodium peroxide equivalent to 15 grams of chlorine per liter was used. After bleaching all of the samples were blued as in methods *a*, *b*, and *c*.

The concentrations of bleaching agent are similar to those used in practice to obtain equal bleaching value. Close examinations were made of the samples by constructing a sample sheet with the different samples placed thereon for comparison. This comparison gave no indication that fumigation of cotton alters the bleaching value.

All of these tests were carried out on all of the samples of cotton.

To confirm these results, five 1-pound samples of Nos. 2 and 2a were treated by method *d*, the following details being observed in connection with the bleaching: After scouring, the cotton was rinsed

30 minutes in cold water, squeezed, and treated 2.5 hours cold with "electrolytic chlorine," 1.46 grams of chlorine per liter; was rinsed well, treated 30 minutes in a 5 per cent solution bisulphite of soda, cold; was rinsed well, and blued with a solution containing three-fourths of a gram vat blue in 10 liters of water.

Samples 10, 11, 14, and 15 were combined into one lot, samples 8 and 9 into a second lot, and samples 12 and 13 into a third lot, and each lot was bleached by the method outlined in the previous paragraph for samples Nos. 2 and 2a.

By comparison of these samples it was evident that there was as much difference in bleaching quality between the two bales of nonfumigated cotton as there was between the bales of fumigated and nonfumigated cotton of the same quality.

### DESCRIPTION OF FURTHER TEST.

Samples of fumigated and nonfumigated Chinese cotton which had been both bleached and blued by a representative cotton mill were submitted for examination. As a result of the bluing process, the sample of fumigated cotton was a more intense blue than the sample of nonfumigated cotton. On receipt, tests were made on these samples for iron to ascertain if there had been a formation of Prussian blue, due to the presence of hydrocyanic acid in the fumigated cotton, which would cause the intensifying of the color of the cotton. Negative results were obtained. The bluing matter was extracted with water until the samples were practically the same color. These water extracts were of different depths of blue. The deepest extract was then diluted until both were of the same shade of blue. The extracted cotton samples were treated again in their respective solutions. The resultant samples were of the same color.

From the above results the conclusion was reached that the increased depth of blue on the fumigated sample was because it had been treated with a greater quantity of bluing and not because of the presence of hydrocyanic acid or because of any chemical change in the fiber such as the formation of hydrocellulose.

### TEST FOR THE PRESENCE OF HYDROCYANIC ACID.

Small specimens from each of the following samples, 2, 2a, and 8 to 15 inclusive, were tested for the presence of hydrocyanic acid as follows:

The sample was covered with a solution of 10 c. c. of distilled water, 5 drops concentrated sulphuric acid, 5 c. c. 2/normal ferrous sulphate and 6 c. c. normal sodium hydroxide heated nearly to a boil, then 5 c. c. 6/normal hydrochloric acid were added.

These tests gave no blue coloration which indicated the absence of hydrocyanic acid in all of the samples at the time of treatment.

### BLEACHING OF YARNS.

The material used in these bleaching tests consisted of yarn made from the following samples of cotton: 1 and 1a, 2 and 2a. Samples 1 and 2 had been fumigated, and samples 1a and 2a were nonfumigated.

All four samples were treated as follows: Boiled for two hours in 10 per cent solution of soda ash at atmospheric pressure, rinsed until free from alkali, then divided into two lots, each lot containing one-half of each of the above four samples. One lot was bleached by method A, the other by method B, as follows:

Method A. Treated cold for two hours in a 2° twaddle solution of bleaching powder, containing 5.82 grams of chlorine per liter, rinsed with cold water, soured with 2 per cent solution of acetic acid, rinsed and antichlored in a 2 per cent solution of sodium bisulphite 30 minutes, then finally rinsed and blued in water containing 1 gram of vat blue in each 13⅓ liters.

Method B. Treated as in method A, except that a solution of electrolized salt containing 2.87 grams per liter of available chlorine was used as the bleaching agent.

The tensile strength and the number of the yarn of all four samples were taken before and after treatment with bleach A and bleach B with the results as shown in Table VII.

TABLE VII.—*Tensile strength of yarns before and after bleaching.*

| Sample No. | Grey. | | | Bleach A. | | | Bleach B. | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of yarn. | Skein breakage, 60 yards. | Single-thread breakage. | No. of yarn. | Skein breakage, 60 yards. | Single-thread breakage. | No. of yarn. | Skein breakage, 60 yards. | Single-thread breakage. |
| 1 | 26.4 | 44.8 | 10.9 | 29.2 | 36.8 | 8.7 | 29.4 | 44.1 | 10.4 |
| 1a | 26.4 | 45.7 | 10.9 | 29.2 | 39.4 | 8.9 | 29.4 | 43.8 | 9.7 |
| 2 | 41.5 | 42.4 | 9.8 | 47.2 | 27.7 | 7.9 | 46.5 | 34.6 | 8.9 |
| 2a | 41.5 | 43.2 | 9.8 | 47.2 | 29.3 | 8.0 | 46.5 | 39.0 | 9.1 |

In this table the tensile strength [1] is given in pounds for the skein breaks and in ounces for the single-thread breaks. The skeins were taken from the same bobbins of which the single threads were tested. From the comparisons of these figures it will be seen that the differences in strength between the fumigated and nonfumigated cotton are so small that it would be unsafe to say that these yarns contained in them any substance such as acids that would reduce the tensile strength of the yarn by releasing the bleaching agent too rapidly.

### DYEING OF YARNS.

Portions from all of the four samples of yarns, namely, 1, 1a, 2, and 2a, were bleached according to method A and method B, except that they were not blued. Instead some of the portions were dyed pink and some were dyed blue with both direct and basic dyes.

[1] See footnote, p. 6.

DIRECT DYES.

*Method of application.*—Dyed in a bath containing 0.1 per cent benzo rhoduline red B, 5 per cent of salt, 0.5 per cent soluble oil. Volume of dye bath equals 25 times the weight of the goods. The goods were entered into the dye bath cold and temperature raised to a boil in 30 minutes, boiled 15 minutes, and allowed to cool in the bath 15 minutes. To obtain the light blue the goods were dyed in the same manner, except 0.1 per cent benzo fast blue BN was used instead of the benzo rhoduline red B.

BASIC DYES.

*Method of application.*—Mordanted in a solution containing 0.015 of a gram of tannic acid in each 100 cc. The goods were entered into the dye bath cold and temperature raised to 190° in 45 minutes, then allowed to cool overnight, rinsed and treated cold for 15 minutes in a bath containing 0.01 of a gram of tartar emetic.

The pinks were dyed in a bath containing 0.05 per cent of rhoduline red B, 0.5 per cent of acetic acid, cold 30 minutes, then raised to 140° during 30 minutes. The blues were dyed as the pinks, except that 0.05 per cent of methylene blue BB was used.

No practical difference was seen between the whites obtained on samples 1 and 1a or on 2 and 2a, respectively, where the same bleaching agent was used. Nor could it be seen that the fumigation had made the cotton either more easy to dye or more difficult to dye with direct or basic dyes.

MERCERIZING OF YARNS.

Samples of yarn made of each of the above four cottons, namely, 1, 1a, 2, and 2a, were mercerized by commercial methods at one of the mills in New Bedford, Mass., and these samples were subsequently tested for their tensile strength and degree of mercerization. In Table VIII the results of the average number of the yarn and tensile strengths,[1] ascertained before and after mercerization, are shown.

TABLE VIII.—*Tensile-strength tests of natural gray and mercerized yarns.*

| Sample. | Natural gray. | | | Mercerized. | | |
|---|---|---|---|---|---|---|
| | No. of yarn. | Strength in pounds per skein of 60 yards. | Strength in ounces per single thread. | No. of yarn. | Strength in pounds per skein of 60 yards. | Strength in ounces per single thread. |
| 1 | 20.84 | 58.6 | 13.8 | 22.0 | 70.0 | 20.2 |
| 1a | 20.84 | 59.9 | 13.9 | 22.0 | 71.2 | 21.0 |
| 2 | 30.5 | 56.0 | 15.0 | 30.7 | 66.0 | 19.9 |
| 2a | 30.5 | 56.5 | 15.3 | 30.7 | 68.1 | 20.2 |

[1] See footnote, p. 6.

From Table VIII it will be seen that the gain in tensile strength due to mercerization is a trifle greater for the nonfumigated than for the fumigated cotton.

The tests for the degree of mercerization were made by dyeing samples of the fumigated and nonfumigated mercerized yarns in 1 per cent benzo purpurin 4 B, 10 per cent salt, 1 per cent soluble oil, 30 minutes at 160°, volume of bath equal to 100 times the weight of goods treated. The same weight samples of mercerized Egyptian yarn were dyed in the same bath after dyeing the fumigated and nonfumigated samples. These exhaust skeins furnished a means of measuring the degree of mercerization, for the better mercerized samples absorb more dyestuff and consequently leave less in the dye bath. In order to ascertain more accurately the degree of mercerization, a sheet of samples was prepared by dyeing mercerized Egyptian cotton with the percentages of dyestuffs shown in Table IX. Salt and soluble oil was used as in method given above, benzo purpurin 4 B being used as the dyestuff.

TABLE IX.—*A set of color standards.*

| Standard No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Dye, per cent | 5 | 4.5 | 4 | 3.5 | 3 | 2.5 | 2 | 1.5 | 1 |
| Salt, per cent | 20 | 20 | 20 | 20 | 20 | 20 | 10 | 10 | 10 |
| Soluble oil, per cent | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 |
| Standard No | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| Dye, per cent | 0.9 | 0.8 | 0.7 | 0.6 | 0.5 | 0.4 | 0.3 | 0.2 | 0.1 |
| Salt, per cent | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Soluble oil, per cent | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Standard No | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Dye, per cent | 0.09 | 0.08 | 0.07 | 0.06 | 0.05 | 0.04 | 0.03 | 0.02 | 0.01 |
| Salt, per cent | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Soluble oil, per cent | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

The samples of colored yarns obtained by dyeing in the exhaust bath were matched against the standards, and it was found that cotton No. 2a (nonfumigated 1½-inch Egyptian cotton) dyed a lighter shade, indicating a greater degree of mercerization than cotton No. 2 (fumigated 1½-inch Egyptian cotton). But results from lots 1 and 1a fumigated and nonfumigated, respectively, were practically identical.

## CONCLUSION.

The results of these tests indicate that the fumigation of cotton with hydrocyanic-acid gas does not affect, to any material extent, the percentages of waste, spinning qualities, tensile strength, bleaching, dyeing, or mercerizing properties of the cotton.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916

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